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(71) Applicant
Gildemeister Aktiengesellschaft

(Incorporated in the Federal Republic of Germany)

Morsestrasse 1, 4800 Bielefeld 11,
Federal Republic of Germany

(72) Inventors
Frithjof Schlle
Horst Goehren

(74) Agent and/or Address for Service
D Young & Co
10 Staple Inn, London, WC1V 7RD, United Kingdom

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(54) Numerically controlled machine tool with two work spindle units

(57) The machine tool for automatically machining both ends of rotationally symmetrical workpieces (10, 17) has two work spindle units (2, 3), one (2) of which can move in the direction of the axis of the spindle while the other (3) can be moved transversely to the axis of the spindle. Associated with the first spindle unit (2) is a tool carrier (23) on a slide (20) movable transversely of the spindle axis a further tool carrier (37) sliding axially is associated with the second spindle unit (3). This latter carrier (37) is a star turret with feed movement in two orthogonal directions coupled with spindle unit (3) feed in a third orthogonal direction.

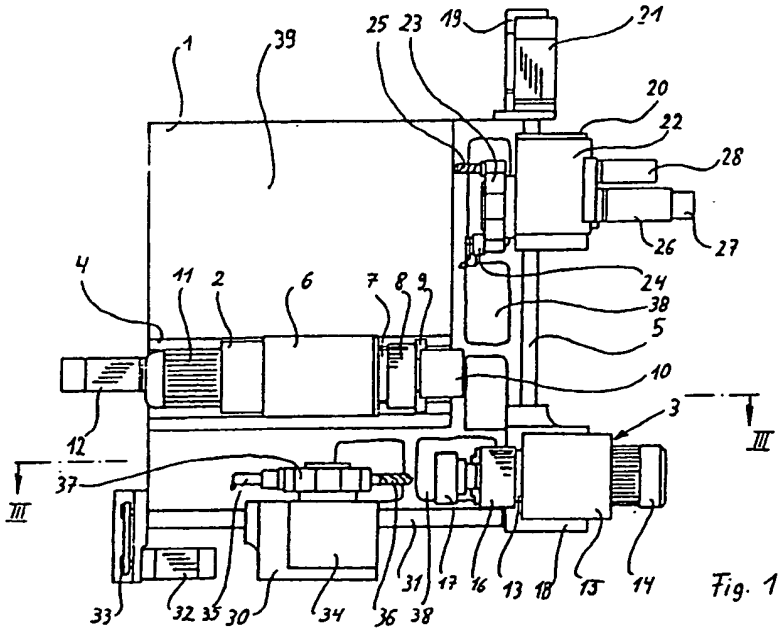

Fig. 1

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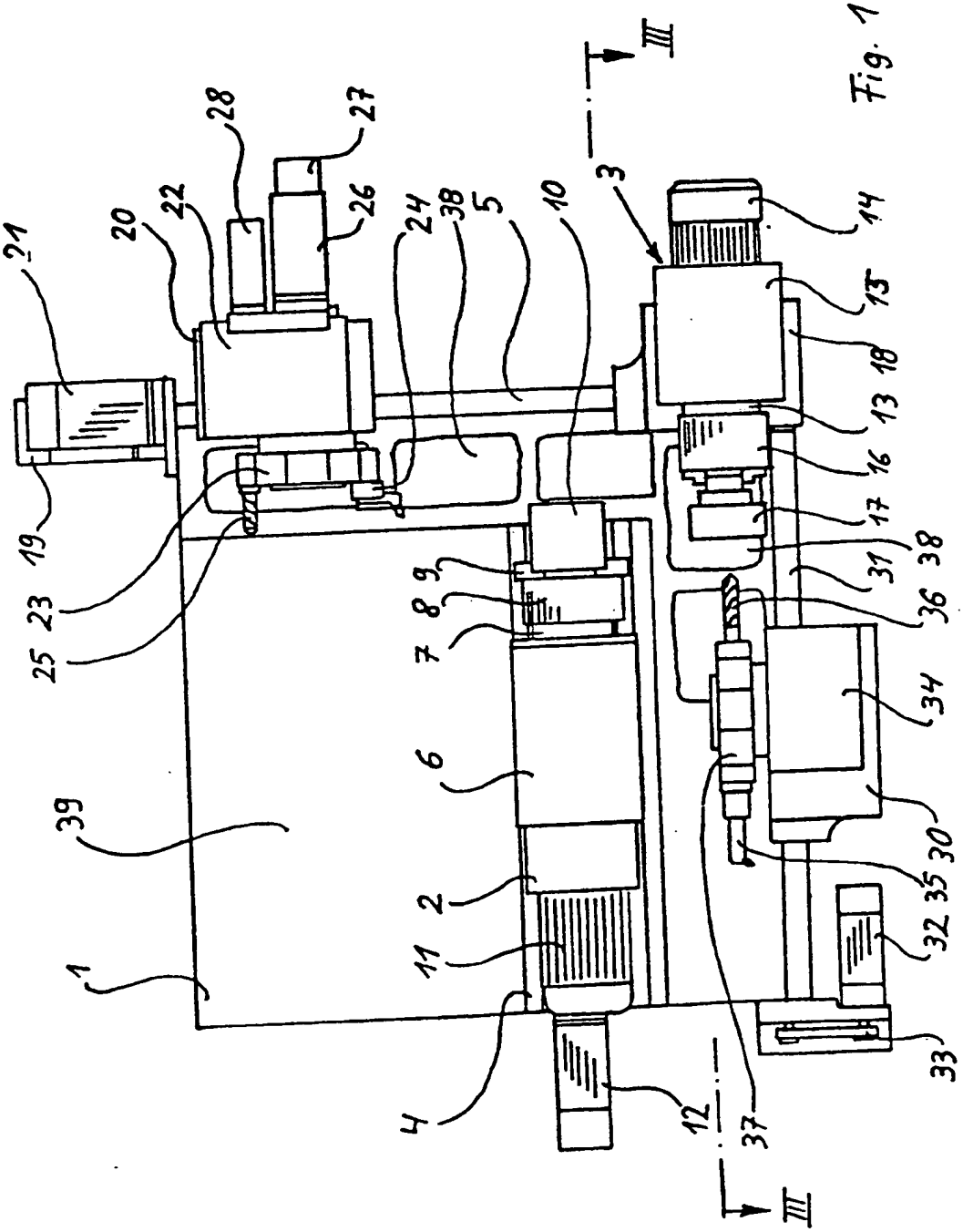

Fig. 1

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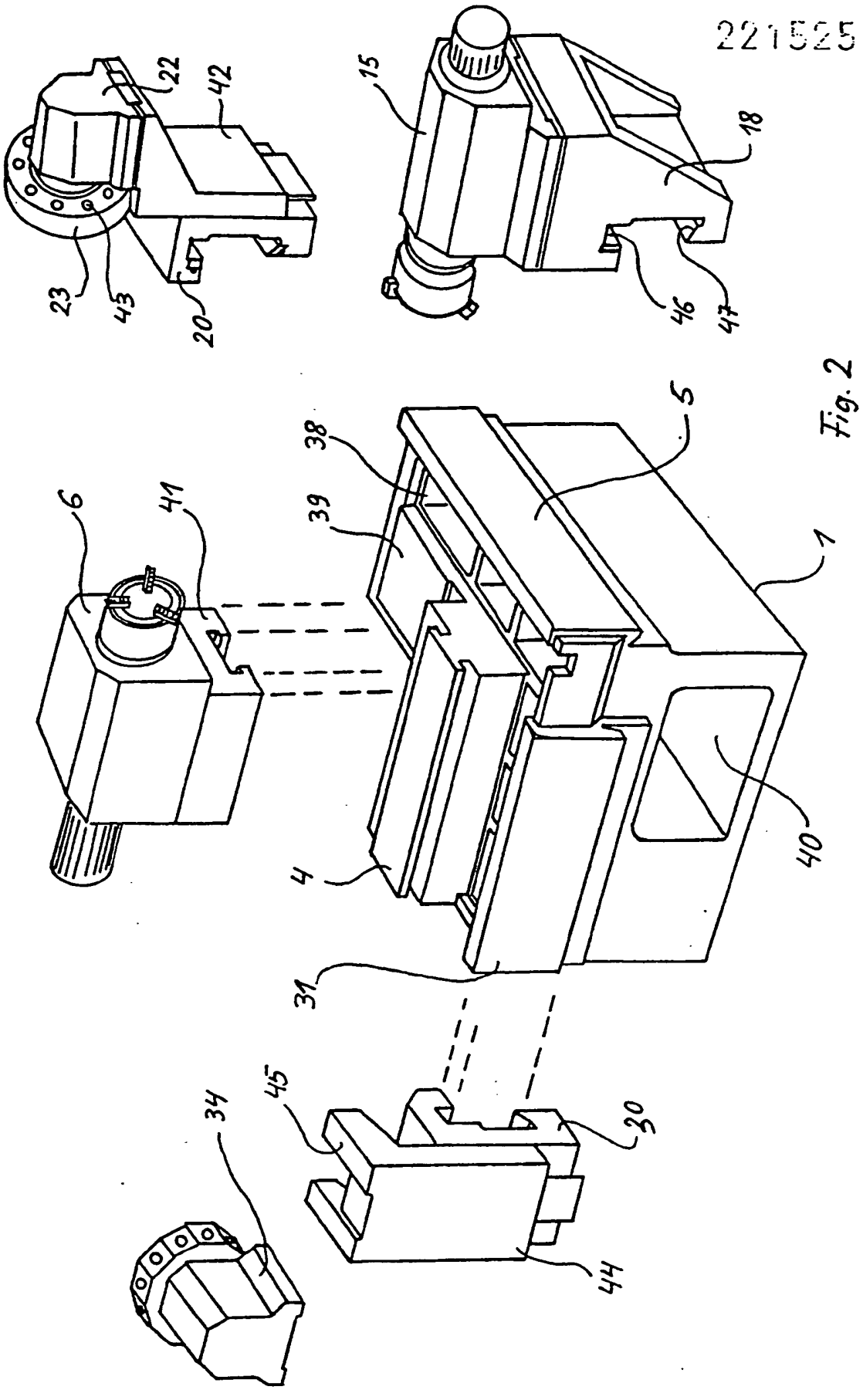

Fig. 2

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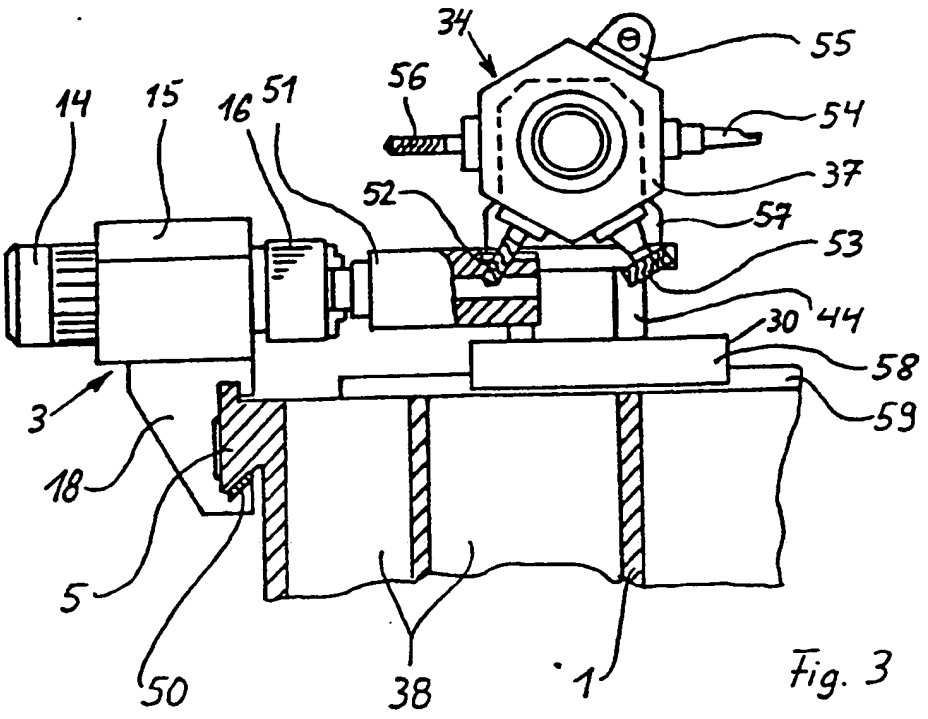

Fig. 3

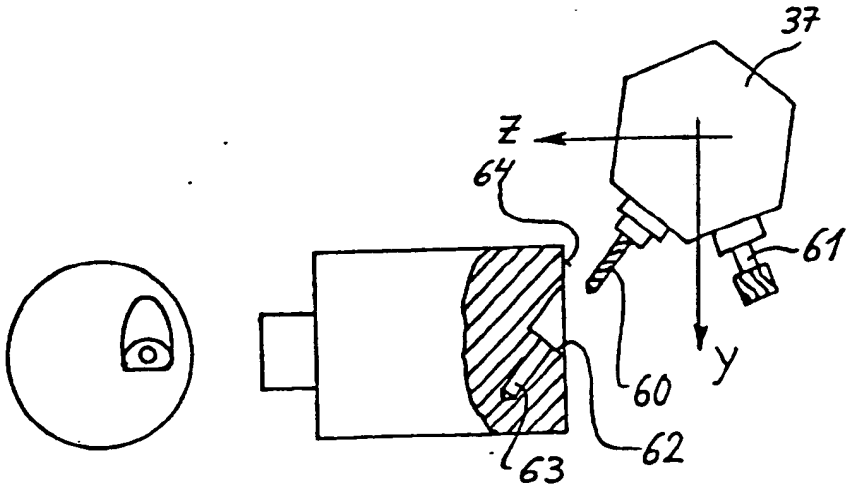

Fig. 4

NUMERICALLY CONTROLLED MACHINE TOOL WITH TWO WORK SPINDLE UNITS

The invention relates to a numerically controlled machine tool for automatic machining of both ends of rotationally symmetrical workpieces and having two work spindle units.

It is becoming increasingly desirable to be able to machine a rotationally symmetrical workpiece in a complete machining process on a single machine tool. By a complete machining process is meant bilateral machining of the rotationally symmetrical workpiece without external intervention utilising various machining processes such as turning, drilling and milling.

Such a machine tool is shown in the leaflet "Multiplex 620" of Messrs. Yamazaki Mazak Corporation. Two coaxially disposed workpiece spindles can be displaced in the axial direction of the spindles. A workpiece machined at one end in one of the workpiece spindles can by virtue of the axial movement of the workpiece spindles, be passed to the other workpiece spindle where it can be machined at its other end. A tool turret with an indexing axis parallel to the spindle axis is associated with each workpiece spindle. The tool turrets can be displaced in a direction radially of the spindle axis. To machine the workpieces, the tool turrets with their tool holding plates have to plunge between the workpieces which are held in the workpiece spindles.

Therefore, for machining purposes, the workpiece spindles must be spaced apart by such a distance that the two longest tools and the longest workpieces to be machined can find space between them without colliding. When the prepared workpiece is passed to the opposite spindle, this distance has to be bridged which takes a relatively long time. The arrangement also limits the machining possibilities, since only limited tool lengths can be accommodated. Despite these restrictions, the machine is very long in its overall size compared with the size of the useful working space. Both central transverse and also longitudinal bores are possible with driven tools.

A further embodiment of a machine tool for complete metal-cutting work is known from DE-GM 87 13 204.4 which shows a lathe comprising a fixed workpiece spindle and a coaxially displaceable counter spindle. The workpieces held by the workpiece spindles can be machined by two

tool turrets mounted on cross slides. The indexing axis of one tool turret is at right angles to the spindle while the indexing axis of the other turret is parallel with the spindle. In addition to freedom in choice of machining, this affords advantages to the utility and application of the tools, but it does however require long paths over which the displaceable workpiece spindles are required to travel when transferring the workpiece. In addition, five controlled feed axles are required. With driven tools, both longitudinal and transverse bores can be made in the workpieces. Milling work is possible only to a limited degree since milling on the tool is dependent upon the milling cutter diameter used.

A further machine tool for bilateral turning of workpieces is known from DE-OS 33 37 198 intended primarily for use in production lines. A plurality of work spindle units are provided, of which the first is arranged for machining the first end while the second is arranged for machining the second end, with mutually facing workpiece holders. Each work spindle unit moves in two horizontal directions at right angles to each other so that without any handling system the workpiece is passed through the whole installation.

Nothing is said concerning the disposition of the tool carriers and the form they take. However, they must be numerically controlled, one tool carrier acting simultaneously on both workpiece spindles. Therefore, a plurality of feed axles are required in order to produce the installation, although it will in each case be designed for just one specific workpiece.

According to the invention there is provided a numerically controlled machine tool for automatic machining of both ends of rotationally symmetrical workpieces comprising two work spindle units mounted for displacement on guideways, having workpiece clamping means on mutually facing sides and each associated with a respective tool carrier slide having a plurality of tools, in which a first of the work spindle units is displaceable in the axial direction of the spindle thereof, a second spindle of the work spindle units is displaceable transversely thereto, a first of the tool carrier slides associated with the first work spindle unit is displaceable transversely of the axial direction of the spindle of the first work spindle unit and a second of the tool carrier slides associated with the second work

spindle unit is displaceable in a direction parallel to the axial direction of the spindle of the second work spindle unit.

Such a machine tool can machine rotationally symmetrical workpieces completely and can be compact and space-saving.

The distance between the two work spindle units is determined by the longest workpiece which is to be clamped, since a coaxial spindle relationship has to subsist only during transfer of the workpiece. For machining the workpieces, one tool carrier performs a transverse movement and this makes the working space available for the tools on the other tool carrier. The movement of the tool carrier is however not utilised for workpiece transport, as with the majority of prior art methods, but serves at the same time as a feed movement. Therefore, the tool carriers require to be moved in only one axis in order to permit biaxial machining on each workpiece. This machining can be carried out freely because the two working spaces are separate from each other and there is no risk of collision. Since both the spindle units and also the tool carriers are moved in only one single direction, i.e. follow only one guide path, this basic embodiment of the equipment can be made very rigid.

With this basic embodiment, the possibility is opened up of achieving further developments without difficulty. It is possible to use as tool carriers, turrets, the indexing axes and tool holders of which are so chosen that they require no additional space and do not therefore make the machine tool any larger.

By disposing the guideways for the tool carriers on vertical faces of the machine bed, space can be provided for an additional slide unit which moves the tools in a Y direction. Above and beyond turning and drilling, along with milling and cutting using rotatingly drive tools, in a plane extending through the axis of workpiece rotation, it is thus possible to use rotating tools for metal-cutting also outside of this plane. This is important for instance if a milling cutter is required to make keyways in a workpiece and their width does not correspond exactly to the tool diameter. Then, the tool must be so moved that the side walls of the keyways remain parallel with each other which is not possible if the turret is performing a pivoting movement.

Optimum tool engagement conditions can be achieved if the angle of inclination of the tool can be adjusted at will, i.e. if the free angle and the cutting angle are variable. This is possible if the indexing spindle of the turret is numerically controlled. The variation in the height of the tool cutting edge which is brought about by the indexing movement of the tool turret can be compensated by the Y-axis. However, the cutting edge of the tool can only be adjusted vertically if it is intended to engage the workpiece for instance above or below the centre of rotation. Presetting of the cutting edge position when setting up the machine is therefore unnecessary.

The making of bores, e.g. oil passages, which extend obliquely to the axis of rotation of the workpiece, or surfaces which are inclined obliquely to the axis of rotation can with a numerically controlled star turret be carried out if the numerically controlled feed axle in the axial direction of the spindle, i.e. the Z-axis, and the numerically controlled Y-axis can be interpolatingly controlled in respect of each other. In this last development stage, any machining which is conceivable with rotatingly driven tools, can be performed. The use of complicated special tools or special tool holders will be unnecessary.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a plan view of a numerically controlled machine tool according to the invention;

Figure 2 is an exploded view of part of the machine tool of Figure 1;

Figure 3 is a sectional view taken on line III-III in Figure 1; and

Figure 4 shows an example of machining being effected by the machine tool of Figure 1.

The plan view in Figure 1 shows a machine tool wherein, on a machine bed 1, two work spindle units 2, 3 are mounted on guideways 4, 5. The work spindle units 2, 3 extend at right angles to each other and are provided on mutually perpendicular faces of the machine bed 1. The work spindle unit 2 comprises a spindle box 6 in which a workpiece spindle 7 is rotatably mounted. Mounted on the workpiece spindle 7 is a chuck 8 which can accommodate, between its jaws 9, a raw workpiece 10

to be machined. The spindle can be driven by an electric motor 11. The work spindle unit 2 can be displaced by a feed motor 12 in the axial direction of the spindle 7 on the guideway 4.

In the workpiece spindle unit 3, a workpiece spindle 13, a spindle drive motor 14, a spindle box 15 and a chuck 16 correspond substantially to the first work spindle unit 2. The chuck 16 is designed to clamp a partially machined workpiece 17 on its machined side. The work spindle unit 3 is mounted on a slide 18 which can be displaced on the guideway 5 transversely to the axial direction of the spindle 13 by a feed motor 19.

Disposed for displacement on the same guideway 5 is a tool carrier slide 20 which has a numerically controllable feed drive 21. Mounted on the tool carrier slide 20 is a tool turret 22, the indexing axis of which is parallel with the axes of the workpiece spindles 7, 13 of the workpiece spindle units 2, 3. The tool turret 22 comprises a tool holder plate 23 into the front face of which turning tools 24, drilling tools 25 or milling-cutting tools can be inserted. Such a turret 22 is usually described as a drum turret. The tool turret 22 includes an indexing motor 26 with a turret 27 which can be numerically controlled. For driving the drilling and milling-cutting tools 25, a further motor 28 is provided. The tools on the tool carrier slide 20 act on the workpiece 10 held by the work spindle unit 2.

For machining of the workpiece 17 held by the second work spindle unit 3, a second tool carrier slide 30 is provided on a guideway 31 which extends parallel with the guideway 4 of the work spindle unit 2. The tool carrier slide 30 is moved on its guideway 31 by a feed motor 32 via a belt transmission 33 and a gear mechanism of known kind. Disposed on the tool carrier slide 30 is a tool turret 34, the indexing axis of which is transverse to the workpiece spindle axis. Accordingly, tools 35, 36 are disposed in bores in a tool holder plate 37 which extend radially with respect to the indexing axis. Therefore, the turret 34 is a star turret. An indexing drive and a drive for the rotating tools are omitted in this illustration since they correspond to those of the tool turret 22.

Underneath the workpieces 10, 20 in the working area of the tools 24, 25 and 35, 36, there are chip apertures in the machine bed 1 to enable pieces cut off the workpieces 10, 17 by the machining to fall

away. At an angle to the guideway 5 of the tool carrier slide 20 and the guideway 4 of the work spindle unit 2 there is a flat surface 39 on the machine bed 1 which is suitable for accommodating workpiece or tool handling means and magazines.

Figure 2 shows further features of the machine tool in relation only to the tool carrier slides 20, 30. To illustrate the unit, an exploded view was chosen in order better to illustrate the sub-assemblies. On the machine bed 1 can be seen the three guideways 4, 5, 31 between which the chip apertures 38 are disposed. The chip apertures 38 open out into a chip tunnel 40 which can accommodate a chip conveyer. On the guideway 4 slides a carriage 41 on which the spindle box 6 is mounted. The guideway 5 holds the slide 18 for the spindle box 15 and the tool carrier slide 20 on which a Y-slide 42 is displaceably mounted. The tool turret 22 is not directly mounted on the tool carrier slide 20 but on the Y-slide 42. The drawing also shows tool holding bores 43 in the tool holding plate 23. The second tool carrier slide 30 which slides on the guideway 31 is provided with a Y-slide 44 an accommodating surface 45 of which is designed to match the star turret 34. The guideway 4 is constructed as a flat guide whereas two guideways 5, 31 form a combination of flat guide 46 and dovetail guide 47. This kind of guideway is particularly suited to accommodate forces and moments of the suspended tool carrier slides 20, 30 and of the slide 18.

Figure 3 shows a section through Figure 1 taken on the line III-III but rotated through 180°. The machine bed 1 is only partly illustrated but does however show two of the vertical chip apertures 38 and the guideway 5 in section. The slide 18 is guided without clearance on the guideway 5 by adjustable pressure strips 50. Mounted on the slide 18 is the work spindle unit 3 in the chuck 16 of which it is intended to clamp a workpiece 51. The workpiece 51 is to be machined by a rotatingly driven drilling tool 52 fixed in the tool holding plate 37 of the star turret 34. Also provided in the tool holding plate 37 are a cylindrical cutter 53, an internal turning tool 54, a transverse drilling means 55 and a further drill 56. A turret housing 57 is mounted on the Y-slide 44 which slides on vertical guideways on the tool carrier slide 30. Of the tool carrier slide 30, only an upper guideway wrap-around 58 can be seen which engages around

the flat guide member 59 of the guideway 31.

The machining process illustrated takes place with the tool 52 driven in a rotating manner. The workpiece 51 is rotated by the spindle drive 14 into the desired angular position and then held. The spindle drive in this case acts as a numerically controlled C-axis. The tool 52 is pivoted by the turret indexing drive into an inclination which coincides with the axis of the bore to be produced. By adjustment simultaneously along the Y-axis and the Z-axis, the tool 52 is then advanced in the direction of its axis. Thus, a bore is produced which is inclined at an angle to the axis of rotation of the workpiece 51. This angle of inclination can be selected at will.

A comparable machining process is shown in Figure 4. The feed directions Y and Z of a tool 60 are shown in the drawings as arrows. In the tool holder plate 37 only the drilling tool 60 and a milling tool 61 are shown. The milling tool 61 has milled a surface 62 while the drilling tool 60 has subsequently made a bore 63. Both shapes were made into an end face 64 of a rotationally symmetrical workpiece outside the central plane and at an angle which is possible only if the following axes are numerically controllable - the rotational axis of the workpiece (C-axis); the vertical feed axis (Y-axis); the feed axis in the axial direction of the workpiece (Z-axis); and the turret indexing axis. Any desired bores and surfaces can be produced on a workpiece.

CLAIMS

1. A numerically controlled machine tool for automatic machining of both ends of rotationally symmetrical workpieces comprising two work spindle units mounted for displacement on guideways, having workpiece clamping means on mutually facing sides and each associated with a respective tool carrier slide having a plurality of tools, in which a first of the work spindle units is displaceable in the axial direction of the spindle thereof, a second spindle of the work spindle units is displaceable transversely thereto, a first of the tool carrier slides associated with the first work spindle unit is displaceable transversely of the axial direction of the spindle of the first work spindle unit and a second of the tool carrier slides associated with the second work spindle unit is displaceable in a direction parallel to the axial direction of the spindle of the second work spindle unit.

2. A numerically controlled machine tool according to claim 1, in which the first tool carrier slide associated with the first work spindle unit is mounted for displacement on the same guideway as the second work spindle unit.

3. A numerically controlled machine tool according to claim 1, in which the first tool carrier slide associated with the first work spindle unit carries a tool turret indexable about an axis parallel to the axis of the first work spindle and the second tool carrier slide associated with the second work spindle unit has a tool turret which is indexable about an axis disposed perpendicular to the axis of the second work spindle unit.

4. A numerically controlled machine tool according to claim 3, in which the tool turret of the first tool carrier slide is a drum turret while the tool turret of the second tool carrier is a star turret.

5. A numerically controlled machine tool according to claim 2, including a machine bed carrying the guideways for the tool carrier slides and the work spindle units, in which the machine bed is cuboid, a first guideway for the first work spindle unit is disposed on the

upper face of the cuboid bed, a second guideway for the second work spindle unit and for the first tool carrier slide is provided on a vertical end wall of the cuboid bed, a third guideway for the second tool carrier slide is disposed on a vertical side wall of the cuboid machine bed and the third guideway extends horizontally and parallel with the first guideway while the second guideway extends transversely with respect to the other two.

6. A numerically controlled machine tool according to claim 5, in which the third guideway on the vertical side wall and the second guideway on the vertical end wall of the cuboid machine bed each comprise an upper flat guide and a lower V-prism guide.

7. A numerically controlled machine tool according to claim 1, in which the first tool carrier slide and/or the second tool carrier slide are displaceable at right angles to the plane which extends through the directions of feed of the work spindle units.

8. A numerically controlled machine tool according to claim 3, in which the indexing movements of the tool turrets are numerically controlled.

9. A numerically controlled machine tool having a tool spindle unit and a star turret with an indexing axis disposed transversely in respect of the workpiece spindle axis, for holding rotatingly driven tools, feed movements being feasible in three orthogonal axes between the tools and the workpiece which is held by the work spindle unit, in which the drive for the indexing movement of the tool holding plate of the star turret can be controlled numerically and the two feed axes which form the plane in which lies the axis of rotation of the tool which it is intended to use, can be interpolatingly controlled.

10. A numerically controlled machine tool for the automatic machining of both sides of rotationally symmetrical workpieces substantially as hereinbefore described and illustrated with reference to the accompanying drawings.

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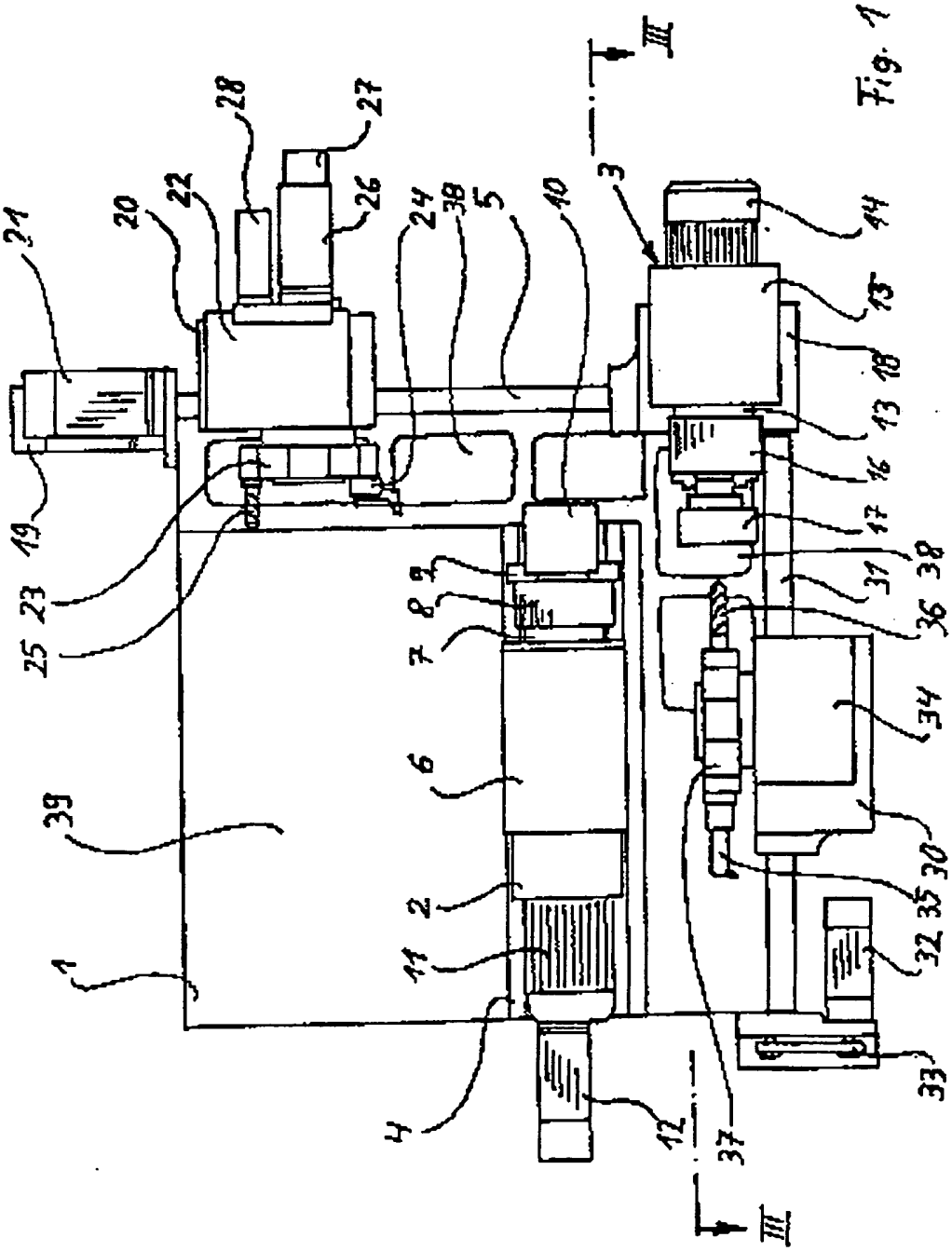

Fig. 1

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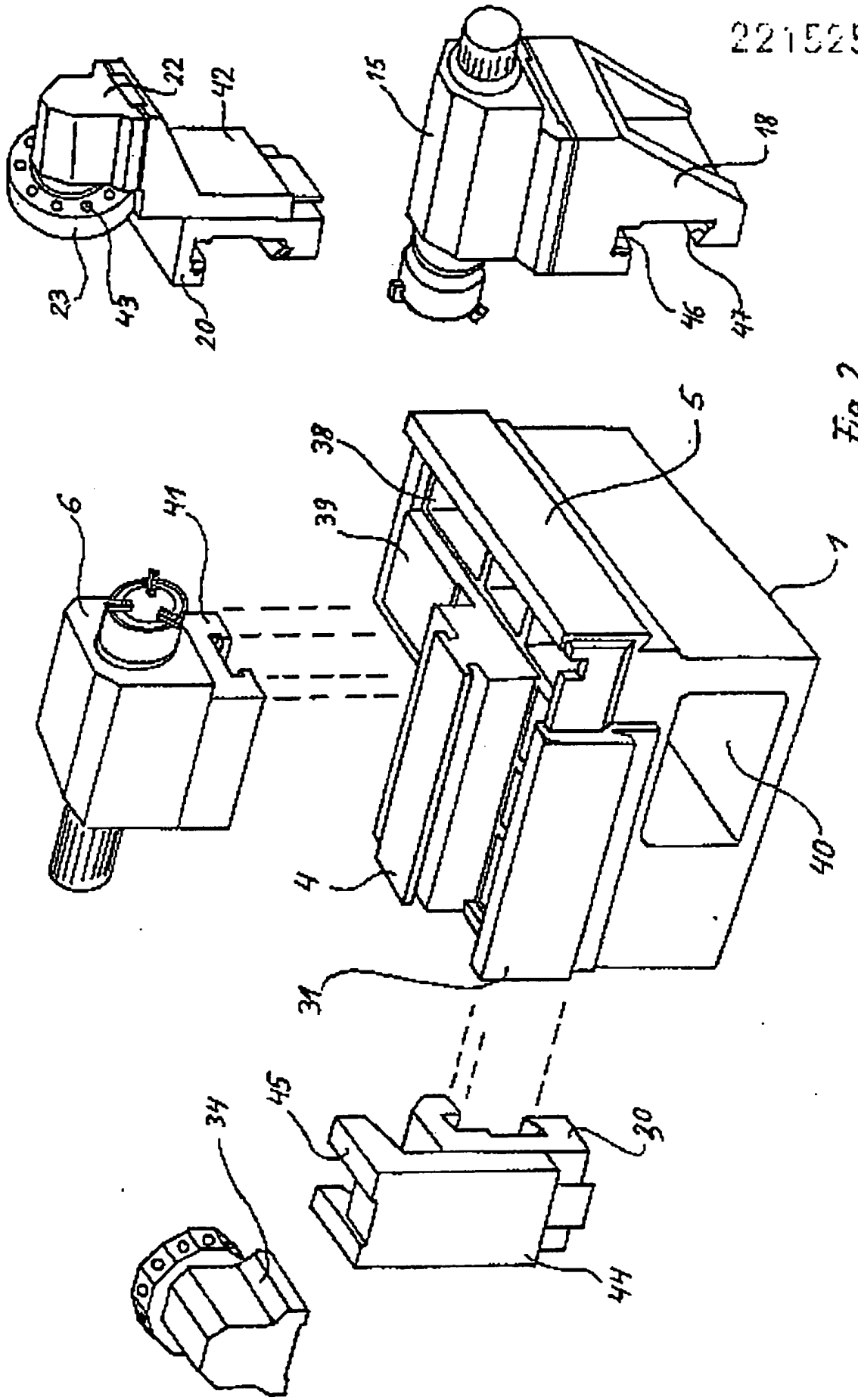

Fig. 2

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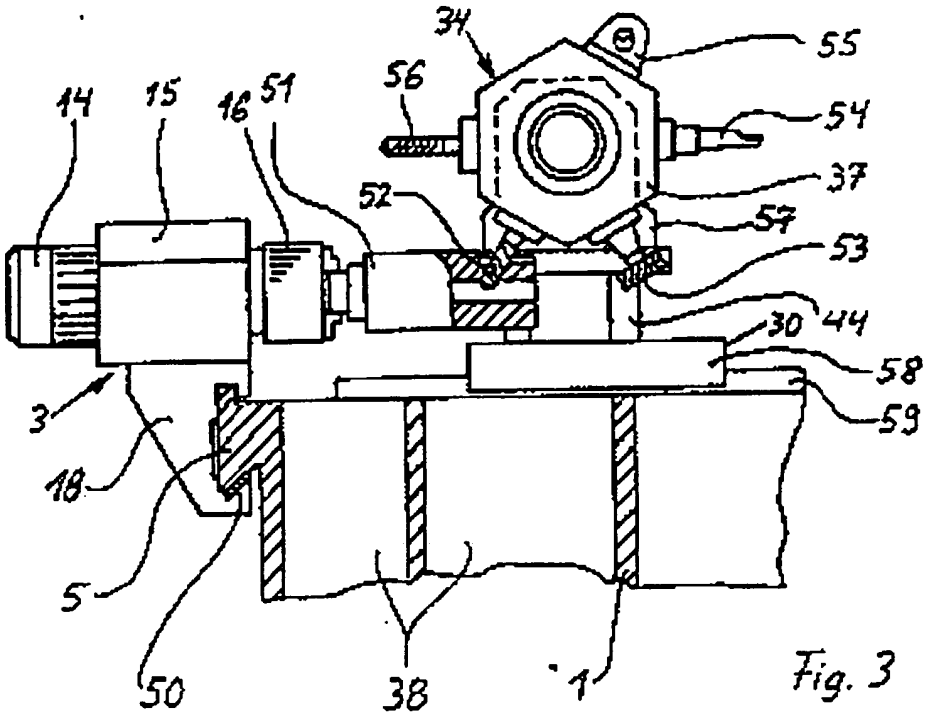

Fig. 3

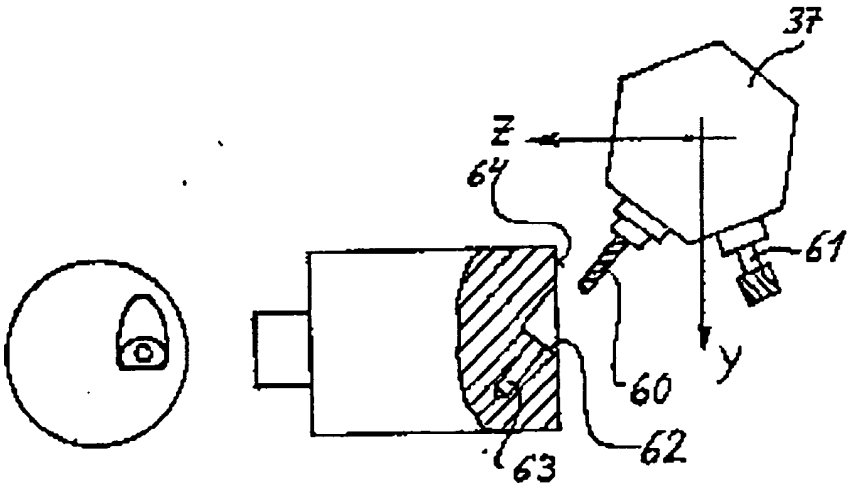

Fig. 4